

DEVELOPMENT OF ADVANCED WEAR- AND CORROSION-RESISTANT SYSTEMS THROUGH LASER SURFACE ALLOYING AND MATERIALS SIMULATION

BENEFITS

Improved coating technologies will result in greater process efficiencies, improved performance, and extended life.

- ➔ Superior wear performance over a wide range of environments.
- ➔ Reduced downtime related to repair and refurbishment of worn and corroded critical components.
- ➔ Improved coatings will lead to energy savings through part life extension.

APPLICATIONS

Each of the IOF industries requires coatings that resist wear and corrosion in complex and harsh processing environments. The ability to produce advanced composite coatings through the addition of hard particles for wear resistance and maintaining corrosion resistance through matrix alloy selection would be ideal.

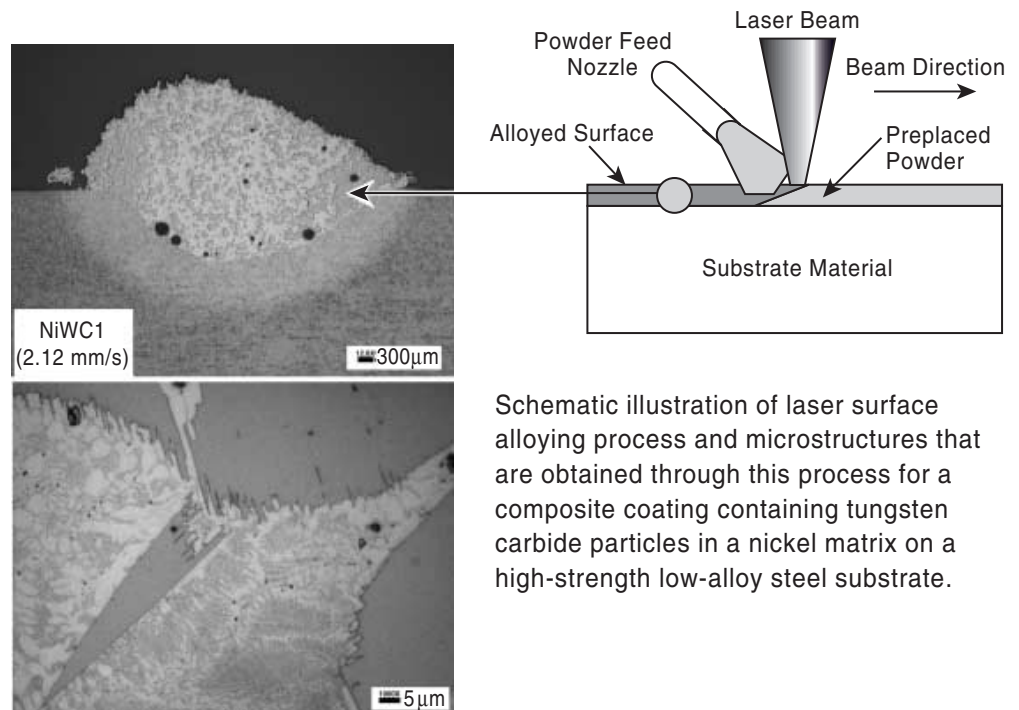
Improved coatings for enhanced wear and corrosion resistance have many applications in the following industries:

- ➔ Agriculture,
- ➔ Aluminum,
- ➔ Chemical,
- ➔ Forest Products,
- ➔ Forging,
- ➔ Heat Treating,
- ➔ Metalcasting,
- ➔ Mining,
- ➔ Process Heating, and
- ➔ Steel.



LASER SURFACE ALLOYING PROCESSING OF ADVANCED WEAR- AND CORROSION-RESISTANT COMPOSITE COATINGS WILL BE DEVELOPED FOR A WIDE RANGE OF INDUSTRIAL APPLICATIONS

All the industries, including mining, mineral processing, agricultural, chemical, pulp and paper, foundry, and primary metal-producing industries, need advanced coatings to improve corrosion (high-temperature and/or chemical) and wear resistance. Among many types of coating technologies, laser surface alloying (LSA) is a versatile process through which one can modify the surface properties of metals and ceramics for required properties by changing the composition of the surface through localized melting and solidification. This process alters the solidified microstructure by alloy-induced transformations, composite strengthening through second phase particles, or a combination of both. However, the design of composite coatings, in which the hard particles provide wear resistance and the matrix provide corrosion resistance, is usually made by a trial-and-error process. This research project will address these issues by developing advanced coatings through improved process development in combination with the development of theoretical predictive models to describe microstructural constituents. This approach is expected to lead to optimum alloy/composite coatings and processing conditions for specific applications.



Schematic illustration of laser surface alloying process and microstructures that are obtained through this process for a composite coating containing tungsten carbide particles in a nickel matrix on a high-strength low-alloy steel substrate.

Project Description

Goal: Development of processing and material simulation techniques for identifying and creating reproducible advanced coatings through the LSA process.

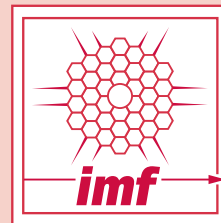
Issues: The design of composite coatings, in which hard particles provide wear resistance and the matrix provides corrosion resistance, is usually made by trial and error, which often leads to nonoptimized processing and coating performance. To improve the microstructural evolution and resulting properties of LSA coatings, various phase-stability, solidification, and kinetic calculations will be performed and experimentally validated. This is expected to lead to new and improved composite-coating systems and optimized processing conditions.

Approach: (1) Extend the laser process, computational thermodynamics and kinetic models to describe the microstructure evolution during LSA processing for well-characterized process conditions. (2) Evaluate the predictions with experimental microscopy and analysis. (3) Use the theoretical models and experimental measurements to develop new advanced composite-coating systems with collaborating industrial members.

Potential payoff: Surfaces modified through LSA composite coating technology can yield high hardness wear, corrosion and oxidation. In addition, they can provide excellent metallurgical compatibility with substrate materials in comparison to traditional coating methods. With these developments, LSA could provide energy, cost, and environmental benefits through decreased part wear and corrosion.

Progress and Milestones

- ➔ Define material requirements for specific industrial applications through previous experience and preliminary experimental LSA.
- ➔ Develop a computational model to describe microstructure evolution during LSA.
- ➔ Modify experimental laser coating process conditions and develop a model to describe thermal cycles experienced by hard particles as a function of laser processing conditions.
- ➔ Validate both the material and process models through comparisons with experimental laser-processed coatings and characterize microstructures.
- ➔ Refine the models for industrial conditions and develop coating technology for application in industry.



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